(54) **Balanced camera mounting**

(57) Camera mounting equipment comprising a wheeled base with a rotatable table (5) mounted thereon. The rotatable table having a balanced pantographic arm pivoted thereon. The arm is composed of a pair of parallelogram links (12,13) which share a common link (22). The linkage is balanced by a weight (36) pivotally mounted on a movable pivot (8) on the table (5). Means are provided for controlling vertical and horizontal movement of a camera mounting platform (18) attached to the other end of the arm. The equipment may be locked or unlocked in any combination of the three axes so that the camera mounting platform may have complete freedom of movement within its operational limits or may be limited to certain straight line or planar movement. The equipment is also counterbalanced and the arm may be remotely controlled using low power motors.
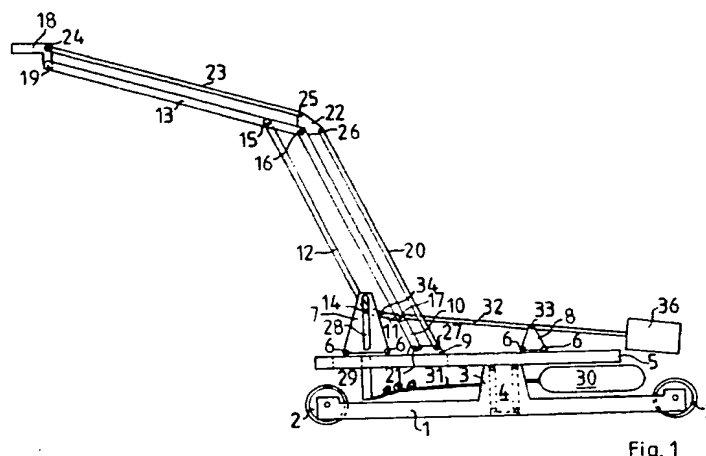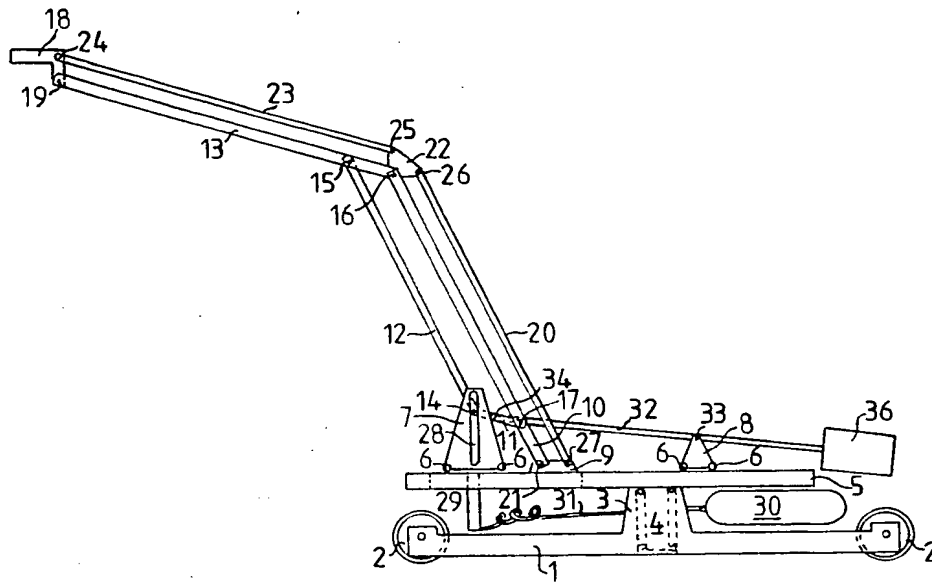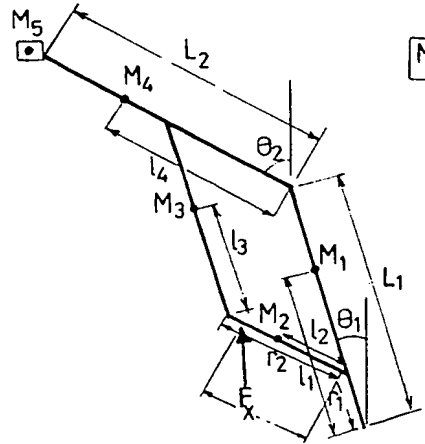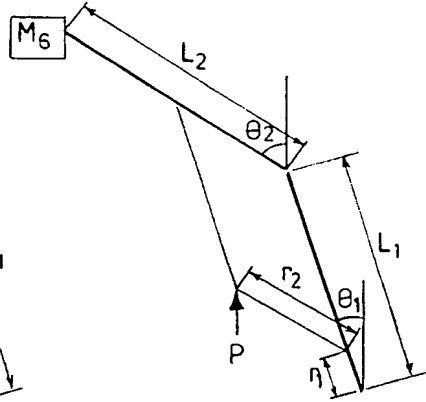
Fig. 1

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Fig. 1

Fig 2

Fig 3

SPECIFICATION

Improvements in or relating to television camera mounting equipment

5 This invention relates to television camera mounting equipment, or the like, and more particu-   5
larly, though not exclusively, to television camera mounting equipment for studio use.
    Television camera mounting equipment such as balanced pedestals at present in use in televi-
sion studios cover most of the desirable features, such as smooth transition of a camera in the
vertical direction and, as the pedestals are normally wheel mounted and operating on a smooth
10 floor, they also cover smooth transition in the horizontal plane. Some of these pedestals will   10
also rotate in azimuth and any one of the three movements may be used independently of the
others. However, assuming, for example, an upward or downward sloping transition were re-
quired, and this is sometimes the case, it is a very hit or miss affair as the operator has to
imagine the changing vertical and horizontal co-ordinates which produce the line of travel, and
15 endeavour to alter the pedestal height, which requires a minimal force to overcome inertia, at the   15
same time as the pedestal is being moved in a straight line across the floor where, due to the
weight difference alone, a comparatively high force is required to overcome inertia. The resulting
wavelike transition which should preferably be a straight line is, more often than not, far from
acceptable.
20   This problem is caused by the appreciable difference in the vertical and horizontal forces   20
required and could be considerably reduced were the forces equally balanced and only a small
guiding force required.
    The same type of problem exists when using pedestals in some other operations, e.g. where
a camera needs to be moved in a particular plane. The horizontal plane can be overcome by
25 moving the balanced pedestal over the floor on its wheels, but the vertical plane suffers the   25
same problems as for the angled transition. It is always the problem of applying the changing
vertical and horizontal co-ordinates manually, and hoping for a smooth transition.
    Balanced arms, also used in the art, do not follow a true vertical as does the pedestal. In
many applications an arm is more appropriate for the task than a pedestal, due to its greater
30 versatility but in the past the lack of true vertical guidance has caused a problem.   30
    It is also desirable that full counterbalance of the mass, comprising camera and arm, is
maintained at all times in elevation and horizontal movement or any combinations thereof so that
only a minimal force is required to transverse in any direction within the working envelope of the
arm and yet full stability and rigidity is maintained at all times both during positional change and
35 at the changed position.   35
    It is a further desirable feature that motion may be constrained to limited planes or directions,
in addition to the aforementioned vertical guidance, as and when required so that an operator
need not concentrate on guidance and only needs to supply the small force necessary for
movement.
40   A still further desirable feature is that the balanced arm may be easily operable from a remote   40
site by such as small electric motors, or the like, controlling the arm movement from remotely
controlled signal lines.
    It is therefore an object of this invention to provide a fully balanced arm wherein the desirable
features of the pedestal are retained and the additional desirable features are incorporated
45 thereby substantially overcoming the problem.   45
    According to the invention we provide a balanced arm for television or the like comprising, a
movable base, a rotatable platform mounted on said base, a first traversable mounting on said
rotatable platform having vertical control means operable on a control pivot off a pantogaph
having its fulcrum arm pivotally located on said rotatable table, a load carrying platform pivotally
50 located at the end of the pantograph proportional arm, linkages forming a first parallelogram on   50
said proportion arm wherein one link is formed on said load carrying platform and a second
parallelogram on said fulcrum arm wherein one link is formed from part of said rotatable platform
and said two parallelograms share a common link; arm mass counterbalancing means pivotally
mounted on a second traversable mounting on said rotatable platform and having its fulcrum
55 pivotally attached to a short link of said pantograph, load counterbalancing means operable on   55
said vertical control means, and guide means for said first and second traversable mountings
wherein said load carrying platform and load retains veticality and may be traversed with full
counterbalance in any plane within its operational limits.
    The invention will now be described, by way of example only, in conjunction with the
60 accompanying schematic diagrams in which,   60
    Figure 1 shows a schematic system according to the invention
    Figure 2 shows the mathematical diagram for proving mass balance of structure and
    Figure 3 shows the mathematic diagram for proving balance of load.
    Referring to Fig. 1 a base (1) preferably of a generally triangular shape for ease of mounting
65 wheels (2) or the like so that the base may be steered or moved in a crabbing fashion i.e. the   65

base may be traversed along a straight line in any selected direction with its three wheels in alignment or may be steered in tricycle fashion. A section (3) which may be part of the base or attached thereto has a journalled shaft (4) of preferably large diameter located therein. Mounted on shaft (4) is a rotatable platform (5) having guides therein (not shown) in which wheels, rollers
5 or the like (6) may run for controlled movement of traversable mountings (7) and (8). A fixed mounting, preferably part of platform (5), provides a fixed link (9) for pivotally mounting the fulcrum (21) of fulcrum arm (10) of a pantograph comprising, in addition, links (11) and (12) and proportion arm (13), joined at four pivot points (14), (15), (16) and (17) so that movement of pivot (14) determines, in conjunction with rotation of platform (5), the position of the proportion
10 arm (13) and hence the position of a load carrying platform (18) pivotally located at the free end (19) of the proportion arm (13). Two parallelograms of links formed from fixed link (9), fulcrum arm (10), link (20) common link (22) link (23), pivotally located on the load carrying platform at pivot (24) to form a short link in conjunction with the pivots (16), (19), (21), (24), (25), (26) and (27) of the two parallelograms ensures that the load carrying platform and a load thereon retains
15 its verticallity irrespective of the pantograph position. Pivot point (21), the fulcrum, provides a fixed reaction point which ensures desirable structural integrity of arms (10) and (13) with the rotatable platform (5).
    A vertical control means, in this example vertical slots milled in traversable mounting (7) for reception of extended ends of pivot (14) provides vertical movement of pivot (14) and pivot (14)
20 is acted upon by a small diameter ram (28) controlled by a gaseous pressure in cylinder (29), located on traversable mounting (7), provided from a relatively large reservoir (30) via suitable piping (31). The pressure on ram (28), being substantially constant, is such that the load on platform (18) is counterbalanced in all positions of the arm. A bar (32) pivoted at a suitable point (33) along its length on traversable mount (8) is pivotally attached at pivot (34) on link
25 (11) of the pantograph and a weight (36) at the opposite end of the bar (32) is of sufficient mass to counterbalance the combined mass of the pantograph and parallelogram links, excluding link (9), and load carrying platform (18) as the combined mass pivots about combinations of pivots (9), (14) and (21). An advantage of this arrangement is that it permits the use of unequal length of proportional arm (13) and fulcrum arm (10) whilst still retaining full counterbalance.
30   In the case of such as a television camera being the load it is normal practice to mount the camera on a pan and tilt head, or the like, to provide additional control. The added weight of the pan and tilt head may be considered as extra load and be counterbalanced by increasing the pressure in cylinder (29).
    Locking means, (not shown) which may be of any known type such as cylinder brakes or
35 friction clamps, may be applied or released at pivot point (14) to lock pivot point (14) in the vertical plane on traversable mounting (7), at wheels or rollers (6) to lock traversable mounting (7) in the horizontal plane on rotatable platform (5), and in journalled shaft (4) to lock the rotatable platform (5) in azimuth. The following table shows the effect of locking and unlocking, either supply singly or in combination, any of the aforementioned locking means.
40

Vertical	Horizontal	Azimuth	Effect on load carrying platform
locked	locked	locked	locked in selected position.
locked	locked	unlocked	peripheral circular motion on horizontal plane.
locked	unlocked	locked	motion in horizontal line.
unlocked	locked	locked	motion in vertical line.
locked	unlocked	unlocked	motion on horizontal plane.
unlocked	unlocked	locked	motion on vertical plane.
unlocked	locked	unlocked	motion on a cylindrical plane.
unlocked	unlocked	unlocked	complete freedom of motion.

55   Manual positional control of the load carrying platform is preferably performed directly at the load carrying platform but remote positional control of the load carrying platform is preferably performed at the control pivot point of the pantograph and may, as the balanced arm is fully balanced, be controlled by three small electric motors, or the like; one for vertical, one for horizontal and one in azimuth; remotely controlled via signal lines. Control by this method has
60 the added advantage that the movement of the load is proportional to the control point displacement provided by the motors.
    It will also be obvious to those skilled in the art that various alterations may be made to the apparatus without departing from the invention. For example, the mass counterbalancing of the arm by weights may easily be replaced by a pneumatic or hydraulic system similar to that for
65 counterbalancing the load or it may be counterbalanced by a spring system such as disclosed in

British Patent Application Number 8122509.

The following calculations, in conjunction with Figs. 2 and 3, shows the mathematical proof for balance of the arm and load respectively.

The mass of each element of the structure is represented by M at its centre of gravity.

Balance of mechanism components

M_1 Mass of links 10, 20 and 22

M_2 Mass of link 11

M_3 Mass of link 12

M_4 Mass of links 13 and 23

M_5 Mass of load platform

F Constant vertical force

In moving from $\theta_1 = \theta_2 = 0°$, loss of potential energy of links is:

$\Delta P.E. = M_1\, l_1\, (I - Cos\theta_1) + M_2\, \{r_1(I - Cos\theta_1) + l_2$
$(I - Cos\theta_2)\} + M_3\, \}(r_1 + l_3)(I - Cos\theta_2)\{ + M_4\}L_1\, (I - Cos\theta_1)\} + I$
$_4(I - Cos\theta_2)\{ + M_5\}L_1(I - Cos\theta_1) + L_2(I - Cos\theta_2)\}$
$\therefore \Delta\ P.E. = (I - Cos\theta_1)\{M_1\, l_1 + M_2 r_1 + M_3(r_1 + l_3) + (M_4 + M_5$
$)L_1\{ + (1 - Cos\theta_2)\}M_2\, l_2 + M_3\, r_2 + M_4\, l_4 + M_5\, L_2\}$

Corresponding work done on force F is:

$\Delta\ W_F = F\ \lhd r_1\ (I - Cos\theta_1) = x(I - Cos\theta_2)\}$

Thus the structure will remain in equilibrium if:

$Fr_1 = M_1\, l_1 + M_2\, r_1 + M_3\, (r_1 + l_3) + (M_4 + M_5)\, L_1$
and $Fx = M_2\, l_2 + M_3\, r_2 + M_4\, l_4 + M_5\, L_2$

Balance of variable camera load

M_6 Mass of camera and mounting

P Constant vertical force

Loss of P.E. of M_6 is:

$\Delta P.E. = M_6\ \{L_1\ (I - Cos\theta_1) + L_2\ (I - Cos\theta_2)\}$

Work done on force P is:

$\Delta W_p = P\ \{r_1\ (I - Cos\theta_1) + r_2\ (I - Cos\theta_2)$

Thus the load will stay in equilibrium if:

$Pr_1 = M_6\, L_1$ and $Pr_2 = M_6\, L_2$

Since $P\ \alpha\ M_6$ in both equations, changes in M_6 can be accommodated by changes in P to maintain conditions for equilibrium.

CLAIMS

1. A balanced arm for television or the like comprising, a movable base, a rotatable platform mounted on said base, a first traversable mounting on said rotatable platform having vertical control means operable on a control pivot of a pantograph having its fulcrum arm pivotally located on said rotatable table, a load carrying platform pivotally located at the end of the pantograph proportional arm, linkages forming a first parallelogram on said proportion arm wherein one link is formed on said load carrying platform and a second parallelogram on said fulcrum arm wherein one link is formed from part of said rotatable platform and said two parallelograms share a common link; arm mass counterbalancing means pivotally mounted on a second traversable mounting on said rotatable platform and having its fulcrum pivotally attached to a short link of said pantograph, load counterbalancing means operable on said vertical control means, and guide means for said first and second traversable mountings wherein said load carrying platform and load retains vertically and may be traversed with full counterbalance in any plane within its operational limits.

2. A balanced arm as claimed in Claim 1 wherein locking means are fitted to said first

traversable mounting to lock said vertical control means.

3.   A balanced arm as claimed in Claim 1 wherein locking means are fitted to said first traversable mounting to lock said first traversable mounting in the horizontal plane.

4.   A balanced arm as claimed in Claim 1 wherein said load counterbalancing means com-
5   prises a small diameter ram controlled by a gaseous pressure from a relatively large reservoir to   5
provide a substantially constant pressure.

5.   A balanced arm as claimed in Claim 1 wherein said arm mass counterbalancing means comprises a bar pivoted at a distance along its length on said second traversable mounting, pivotally attached to a link of said pantograph at one end and having a weight of sufficient mass
10 at its other end to counterbalance the combined mass of the pantograph, parallelogram links,   10
excluding said link formed on part of said rotatable platform, and said load carrying platform.

6.   A balanced arm as claimed in Claim 1 wherein said rotatable platform is lockable to said base to prevent movement in azimuth.

7.   A balanced arm as claimed in Claims 2, 3 and 6 wherein the selection and operation of
15 locking means provides an effect on said load carrying platform substantially as tabulated in the   15
specification.

8.   A balanced arm as claimed in any previous Claim wherein the fulcrum of the pantograph is pivoted on the rotatable platform to provide a fixed reaction point to ensure the desirable structural integrity of the fulcrum arm and proportion arm with the rotatable platform.